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(54) Projectile resistant shield for protective garments

(57) A laminar material which is resistant to the impact of projectiles, especially ballistics, and sharp instruments, comprises a plurality of layers of textile fabric and at least one layer comprising fibres which are perpendicular to the plane of the said textile fabric layers. Preferably, the fibres 4 are located between and attached to, a pair of textile fabric layers 3, 4, this assembly being laminated with further textile fabric layers 1. Many other arrangements are envisaged, including the provision of more than one perpendicular fibre layer. One or more of the layers may be impregnated with resin and other layers may be provided eg of aramic, acrylic resin, aluminium, titanium, steel or glass plate; wire mesh, closed-cell foam etc. The material may be incorporated into anti ballistic garments.

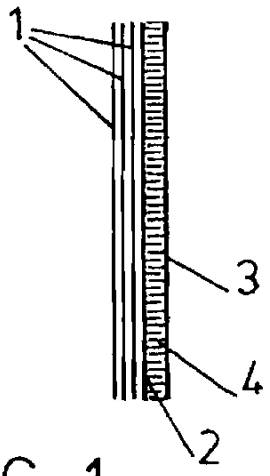

FIG. 1

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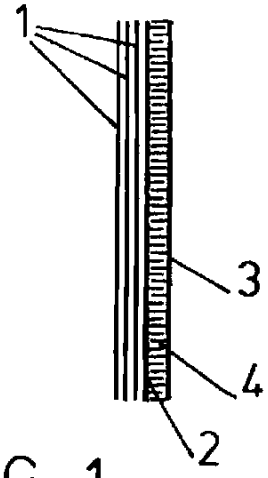

FIG. 1

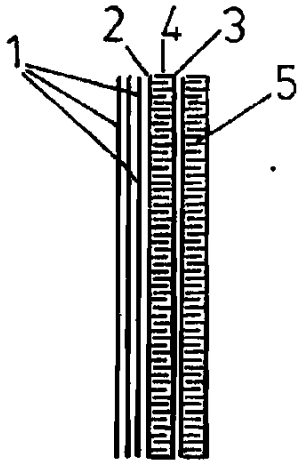

FIG. 2

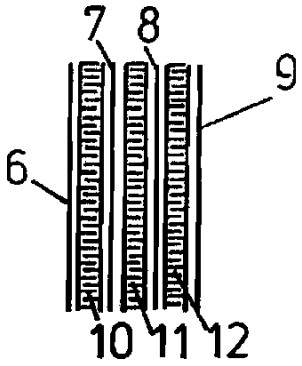

FIG. 3

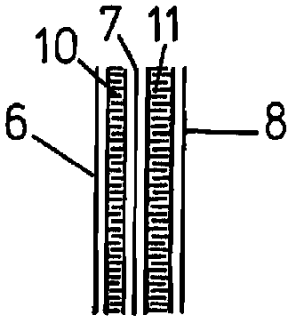

FIG. 4

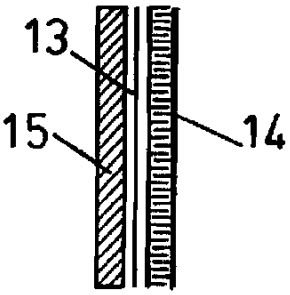

FIG. 5

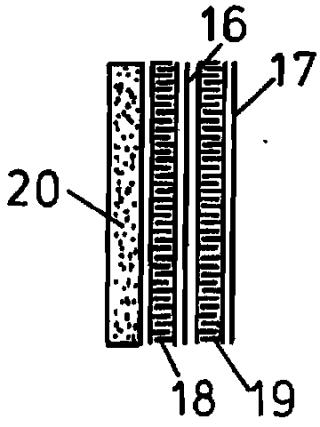

FIG. 6

Protective shield

The present invention relates to protective shields, and in particular to protective shields which can be incorporated in clothing to provided body armour.

Body armour typically consists of layers of textile fabric material formed from fibres of high tensile strength, for example aramid fibres. The layers of fabric are arranged in an order that should cause a bullet or other projectile to mushroom and/or fragment so as to deliver up its kinetic energy to the fibres. The resultant effect on the layers of fabric when say a bullet is stopped is to cause an indentation on the backface of the body armour, that is the side of the body armour which faces towards the wearer. The depth and diameter of this backface indentation is an accepted measure of the trauma inflicted upon a human body protected by the body armour. The trauma can be reduced by introducing separate "trauma" packs formed from for example foam, plastics, feathers and felt between the body armour and the wearer's body. The effectiveness of body armour and trauma packs can be enhanced by grading the various layers of textile fabric into degrees of coarseness of weave, coatings of resin, and/or the introduction of adhesives. The layers of fabric are deformed to varying degrees depending upon their distance from the strike face, that is the surface of the armour struck by the projectile.

Three dimensional fabrics are known which comprise two parallel layers of fabric interconnected by a dense mass of fibres extending perpendicular to the two layers and secured to both of the layers. One such commercially available fabric is fabricated from polyester yarn. One of the suggested uses of this

material is as a cushioning material, for example in running shoes. The suggested uses are essentially concerned with absorbing shocks applied to a surface (the insole of a running shoe) as a result of the impact on the running shoe on another surface (the road surface). No suggestion has been made that this material can provide significant cushioning against the effects of a strike by a small object such as a bullet.

The conventional approach to body armour has been to assume that fibres incorporated in the armour should extend perpendicular to the strike face so as to "spread" the impact of the projectile on the strike surface away from the point of impact. It has now surprisingly been discovered that an alternative approach can provided better results.

According to the present invention there is provided a protective shield comprising first and second layers of textile material arranged substantially parallel to each other, a plurality of textile fibres extending perpendicular to and connected to both of the first and second layers, and a plurality of further layers of textile material comprising fibres extending parallel to the said first and second layers.

A projectile hitting a protective shield as defined above is in effect travelling parallel to the fibres extending perpendicular to the first and second layers. Intuitively one might expect that such an arrangement would provided less resistance to penetration than an equivalent mass of fibres extending perpendicular to the direction of motion of the projectile. In practice however it has been found that this is not the case, possibly because of the

space in between the first and second layers.

The amount of energy absorbed as a result of the collapse of the fibres extending between the first and the second layers is a function of fibre length, fibre material, fibre density and the mechanical properties of the first and second layers. Preferably the combined structure of the first and second layers and the fibres extending therebetween (hereinafter "the matrix") has a thickness of from 1 to 10 millimetres and its characteristics are determined by heat treatment, impregnation with resin, adhesive joining to a parallel matrix (which maybe have a different structure) or the joining by adhesive or other means to other layers of woven, knitted or felted fabrics.

Tests have shown that the above system is effective in reducing trauma and also is highly cost-effective as it reduces the number of textile layers of high tensile-strength fibres required for a predetermined penetration resistance. Furthermore, effective armour can be produced which is relatively light, works effectively when wet, and is buoyant in water. These are important practical advantages in use.

A typical armour structure might consist of six or more layers of aramid fibre woven to form a textile cloth and one or more layers of the matrix. The matrix could be fabricated from polypropylene fibres with a density of 0.90 g/cm^3, that is lighter than water. The overall ratio of aramid to matrix is determined to give the required balistic integrity and also buoyancy in water. Buoyancy of the system can be further improved if polyethylene woven fibre is used, such as that sold under the trade names

Dyneema SK60 or Spectra, having a quoted density of 0.97g/cm^3, and a matrix containing polypropylene fibres and/or polyethylene fibres. The armour may comprise mixtures of various fabrics woven, knitted or felted from aramid, polyethylene, glass, nylon or polyamide fibres, or other such fabrics both in the matrix or in the other layers.

Tests have shown that the protective shield in accordance with the invention is effective in stopping projectiles and also attacks by sharp instruments such as knives, resistance to penetration by knives being enhanced if the matrix is treated with a resin and/or heat. Further improvements to penetration resistance can be achieved if the protective shield has incorporated within it woven glass reinforced modified acrylic resin.

If it is desired to provide a protective shield which is capable of stopping high velocity or low velocity armour piercing bullets a ceramic plate, glass plate or metallic plate may be introduced into the shield on or adjacent the strike face on the shield. Such plates may have a composite textile backing. Tests have shown that a plate fixed directly onto a matrix layer at the strike face of the shield and mounted using epoxy, vinylester, polyester resin or adhesives proved an effective defence against high velocity and armour piercing low velocity bullets. However, if such plates are incorporated it is advisable to introduce in addition a closed-cell foam layer to maintain buoyancy in water.

Six embodiments of the present invention will now be described, by way of example, with reference to Figures 1 to 6, each embodiment of the invention as illustrated being intended for use with the

left-hand side of the structure in the drawings facing the direction from which it is expected that projectiles will be fired.

With reference to Figure 1, this shows a structure comprising multi-layers of aramid fibre 1 positioned in front of a matrix comprising a first layer 2, a second layer 3, and a mass of fibres 4 extending perpendicular to the layers 2 and 3, the fibres 4 being secured to both of the layers 2 and 3.

Referring to Figure 2, this shows a similar arrangement to that of Figure 1 with the provision of a further matrix layer 5 identical to that comprising components 2, 3 and 4.

With regard to Figure 3, this shows an embodiment comprising four layer, 6, 7, 8 and 9 of woven aramid fibres between which are sandwiched three matrix layers 10, 11 and 12.

Referring to Figure 4 this arrangement is similar to that of Figure 3 except for the omission of the matrix layer 12 and the aramid fibre layer 9.

Referring to Figure 5, this shows a protective shield comprising a layer of woven aramid fibres 13 sandwiched between a matrix 14 and a front layer of woven glass reinforced modified acrylic resin 15.

Referring to Figure 6, this shows a protective shield comprising two layers 16 and 17 of woven aramid fibres, two matrix layers 18 and 19, and a front layer 20 of ceramic, glass or metal tile material. Such a shield provides an effective defense against high velocity or low velocity armour piercing bullets.

Referring to the described embodiments in which the woven layers are referred to as being fabricated from aramid fibres, it will be appreciated that

alternative anti-ballistic textile fibres may be used, for example polyethylene, glass, polypropylene, polybenzothiazole, nylon or polyamide. Similar materials may be used to form the various matrix layers comprising first and second layers interconnected by fibres connected to both of those first and second layers. The fibres of the matrix layer or layers may be impregnated with resin and/or subjected to heat treatments. The or one of the matrix layer may be adhesively secured to adjacent layers and/or sewn to adjacent layers. Different textile fibres may be used in a single matrix layer and the or one of the matrix layers may be faced with a plastics material. As a further protection against projectile penetration a wire mesh layer may be incorporated in the shield.

CLAIMS:

1. A shield for protection against projectiles and sharp instruments, comprising a plurality of parallel layers of textile fabric and at least one further layer composed of fibres which are substantially perpendicular to the plurality of layers of textile fabric.

2. A shield according to claim 1, in which the textile fabric is formed from fibres of aramid, polyethylene, glass, polypropylene, polybenzothiazole, nylon or polyamide.

3. A shield according to claim 1 or 2, in which the fibres of the said at least one further layer are formed from aramid, polyethylene, glass, polypropylene, polybenzothiazole, nylon or polyamide.

4. A shield according to any preceding claim, wherein the fibres of the said at least one further layer are impregnated with resin.

5. A shield according to any preceding claim, wherein the fibres of the said at least one further layer are heat treated.

6. A shield according to any preceding claim, wherein the said at least one further layer is adhesively attached to one or more of the layers of textile fabric.

7. A shield according to any preceding claim, wherein said at least one further layer is sewn or attached by flexible staples to one or more of the layers of textile fabric.

8. A shield according to any preceding claim, wherein a plurality of said further layers are interleaved with layers of said textile fabric.

9. A shield according to any preceding claim, wherein said at least one further layer comprises different textile fibres.

10. A shield according to any preceding claim, wherein said at least one further layer is faced with a plastics material.

11. A shield according to any preceding claim, wherein the textile fabric layers comprise different textile fibres.

12. A shield according to any preceding claim, wherein the textile fabric layers comprise different constructions.

13. A shield according to any preceding claim, wherein at least one of the fabric layers is impregnated with resin.

14. A shield according to any preceding claim, wherein at least two of the fabric layers are adhesively bonded together.

15. A shield according to any preceding claim, wherein the shield is inherently bouyant.

16. A shield according to any preceding claim, comprising at least one ceramic, modified acrylic resin, aluminium, titanium, steel or glass plate.

17. A shield according to any preceding claim, comprising a wire mesh incorporated within its structure.

18. A shield according to any preceding claim, comprising a closed-cell foamed plastic or elastomeric material incorporated within its structure.

19. A shield according to any preceding claim, comprising a fabric cover.

20. A shield substantially as hereinbefore described with reference to the accompanying drawings.

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